DUQUESNE LIGHT COMPANY

BEAVER VALLEY POWER STATION

UNIT 2

CYCLE 3

STARTUP PHYSICS TEST REPORT

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BEAVER VALLEY POWER STATION

Unit 2, Cycle 3 Startup Test Report

INTRODUCTION:

Beaver Valley Unit 2 was shutdown on September 4, 1990 for its Second Refueling Outage. During the outage, 68 of 157 fuel assemblies were replaced with a triple split batch: 20 fuel assemblies of 3.6 w/o enrichment, 12 assemblies of 3.8 w/o enrichment and 36 fuel assemblies of 4.2 w/o enrichment. The fresh fuel rods are based on the standard design with natural uranium in the top and bottom six inches. Assemblies with Integral Fuel Burnable Absorbers (IFBA) have arrangements of 100 and 128 rods with boride-coated pellets in the central 120 inches. A region of unpoisoned fuel six inches in length is found between the natural uranium and the boride-coated fuel in these IFBA fuel assemblies.

This report describes the startup test program applicable for the Cycle 3 reload core design verification for BVPS, Unit 2. This testing program consisted of the following measurements conducted from November 15, 1990 through November 30, 1990:

1. Control rod drop times
2. Initial criticality
3. Boron endpoints
4. Control bank worths
5. Temperature coefficient
6. Reactivity computer checks
7. 30% power symmetry check
8. Incore/Excore cross-calibration
9. Power distribution measurements at 74%, 90% and 100% reactor power

The results of these startup tests are summarized in this report and comparisons are made to predicted design values and applicable BVPS Technical Specification Requirements.

TEST SUMMARIES:

2BVT 1.1.1 "Control Rod Drop Time Measurements"

PURPOSE:

The purpose of this test was to determine a drop time for each full-length Rod Control Cluster Assembly (RCCA) at Hot Standby and full RCS flow conditions. The test also verifies that the Digital Rod Position Indicators are within ±12 steps of the group demand counters for each control rod.

TEST DESCRIPTION:

A single RCCA Bank is withdrawn to the maximum full-out position (231 steps). At each 24 step increment, rod position is recorded from the RPI control board display and the Safety Parameter Display System for comparison with the group step counter indication.

After rod withdrawal, stationary gripper coil voltage, a 120 volt 60 Hz timing trace, and the sum of the signals from the Digital Rod Position Indication Data Cabinets A and B detector/encoder cards are connected to a multichannel visicorder. At the power control cabinets, the movable gripper and stationary gripper fuses are removed to initiate the rod drop. Each of the 48 rod cluster assemblies is tested in this manner and the rod drop times are determined from the visicorder traces.

RESULTS:

The test commenced at 0107 on November 15, 1990 and was completed at 0840 hours on November 16, 1990. The drop times of all 48 rods were well within the BVPS Unit 2 Technical Specification Requirement of < 2.2 seconds, with the slowest time being 1.44 seconds for rod B-6 at hot full RCS flow.

2BVT 2.2.1 "Initial Approach to Criticality After Refueling"

PURPOSE:

The purpose of this test was to: (1) achieve initial criticality; (2) determine the point at which nuclear heat occurs and establish the Low Power Physics Testing Band (LPPTB); (3) verify the proper calibration of the reactivity computer.

TEST DESCRIPTION:

Initial conditions were established on November 20, 1990 at 0326 with the following conditions: shutdown banks fully withdrawn, control banks fully inserted, boron concentration at 2101 ppm, RCS temperature at 547 F, and RCS pressure at 2262 psig.

The control banks were withdrawn in 50 step intervals until Control Bank D reached 160 steps. During control rod withdrawal, the Inverse Count Rate Ratio (ICRR) was monitored at 50 step increments and decreased from 1.0 to 0.43.

The ICRR was renormalized to 1.0 and dilution to criticality started at 0400 at a rate of 46 gpm (≤1000 pcm/hr). During the dilution, ICRR data was obtained at 20 minute intervals and plotted versus boron concentration and makeup water added. At 1120, on November 20, 1990 after 14,000 gallons of primary makeup water had been injected, criticality was achieved.

Following the recording of criticality data, flux was increased towards nuclear heat. Nuclear heating was observed at 6.9×10^{-7} amps on the reactivity computer.

A reactivity computer calibration check was then performed using the reactor with positive reactivity insertions of 24 pcm, 32 pcm, and 59 pcm. The doubling times were measured and predicted reactivity compared to measured for each insertion.

2BVT 2.2.1 was completed at 1555 on November 20, 1990.

RESULTS:

The All Rods Out (ARO) critical boron concentration corrected for rod position was calculated to be 1670 ppm which was within the acceptance criteria of 1671 ± 50 ppm.

The LPPTB was set at 2.5×10^{-9} amps to 3×10^{-8} amps based on an observed nuclear heating point of 6.9×10^{-7} amps and a background current reading of 2.5×10^{-10} amps for power range detector N44.

The measured errors for the reactivity computer calibration check were 0.31%, -0.84%, and 1.26%, which was within the acceptance criteria of ± 4%.

2BVT 2.2.2 "Core Design Check Test"

PURPOSE:

The purpose of this test was to verify the reactor core design from hot zero power to 100 percent reactor power, and to perform the initial incore/excore cross-calibration.

TEST DESCRIPTION:

The test was divided into five parts:

Section A covered Low Power Physics Testing. These tests are performed in the Low Power Physics Testing Band at less than 5% reactor power. They include the following measurements: boron endpoints, boron dilution worth measurement of the reference bank (CBB), rod swap bank worths, differential boron worth, and an isothermal temperature coefficient measurement.

Section B involved performing a full-core flux map prior to exceeding 30% reactor power to verify core symmetry and proper core loading.

Section C required a full-core flux map to be obtained between 40% and 75% reactor power to ensure the measured peaking factors were within their applicable Technical Specification Limits.

Section D required that an incore/excore calibration be performed between 50% and 100% reactor power. This involved performing 2BVT 2.2.3, "Nuclear Power Range Calibration", in which a series of flux maps are performed at various axial offsets.

Finally, Section E involved performing a full-core flux map at 100% reactor power. This map served as a calibration check for the incore/excore calibration and verified that the power distribution limits of the Technical Specifications were not exceeded.

RESULTS:

Boron Endpoints:

The All Rods Out (ARO) critical boron concentration was measured to be 1648 ppm which was within the acceptance criteria of 1671 ± 50 ppm.

The Control Bank B-in critical boron concentration was measured to be 1488 ppm which was within the acceptance criteria of 1497 ppm ± 15% (1272.4 ppm to 1721.6 ppm).

Temperature Coefficient:

The ARO, HZP Isothermal Temperature Coefficient (ITC) was determined to be -2.12 pcm/F which was within the acceptance criteria of -2.95 ± 3 pcm/F.

Subtracting out the predicted design value of the Doppler Coefficient (-1.66 pcm/F) from the measured ITC, the inferred Moderator Temperature Coefficient (MTC) was calculated to be -0.46 pcm/F. This value meets the requirements of the BVPS Unit 2 Technical Specifications which requires the MTC to be between -50 pcm/F and 0 pcm/F. The station has in place procedures to ensure that a negative MTC is maintained throughout cycle 3 core life.

Differential Boron Worth:

The measured differential boron worth was 7.80 pcm/ppm which was within the acceptance criteria of 7.66 pcm/ppm ± 15% (6.51 pcm/ppm to 8.81 pcm/ppm).

RCC Bank Worths:

The boron dilution method of rod worth measurement was used to determ[illegible] worth of the reference bank (Control Bank B) for rod swap. The wort[illegible] remaining control and shutdown banks were obtained relative to [illegible] measured worth, predicted value, and percent difference for each RC[illegible] total RCC worth are listed in Table 1. All the measured values were wi[illegible] acceptance criteria for this test.

Reactivity Computer:

The reactivity computer calibration was checked prior to Low Power Ph[illegible] Testing (LPPT) and every 24 hours during the test using the exponential generator. In addition, an operational calibration check using the reactor was also performed following initial criticality. In all cases the comput[illegible] error was within the 4% acceptance criteria, with the highest measured err[illegible] being 2.36%.

30 Percent Power Symmetry Check:

A full-core flux map was performed on November 24, 1990 at approximately 30% reactor power with Control Bank D at 183 steps to determine the initial flux distribution in the core. Table 2 lists the values for quadrant tilt and maximum deviation from predicted assembly powers for the 30% flux map. All measured values were within the acceptance criteria for the test.

74 Percent Power Flux Map and Incore/Excore Calibration:

On November 26 and 27, 1990 2BVT 2.2.3, "Nuclear Power Range Calibration" was performed at approximately 74% reactor power. This test involved a full-core and six quarter-core flux maps obtained at various axial offsets to calibrate the excore detectors and verify core peaking factors. The results of the full-core flux map are shown in Table 2.

All measured values were within the acceptance criteria. The measured Fxy corrected for uncertainties was 1.7355 for the 74% flux map. Technical Specifications require this value to be less than Fxy(RTP) (1.65) and Fxy(LIM) (1.7760 for 74% power). The measured Fxy was less than Fxy(LIM), however it exceeded Fxy(RTP). This required an additional power distribution check to be done at 90% power per Technical Specification 4.2.2.2.d.1.

90 Percent Power Flux Map:

On November 28, 1990 a full-core flux map was performed at 90% reactor power. This map was performed to satisfy Technical Specification 4.2.2.2.d.1 surveillance requirements due to the measured Fxy exceeding Fxy(RTP) from analysis of the 74% power flux map. The results of the full-core flux map are shown in Table 2. All measured values were within the acceptance criteria. The measured Fxy corrected for uncertainties was 1.7062. Technical Specifications require this value to be less than Fxy(RTP) (1.69) and Fxy(LIM) (1.7276 for 90% power). Once again, Fxy was less than Fxy(LIM), however it was greater than Fxy(RTP). The full-core flux map at 100 percent power would be used to satisfy surveillance requirements of Technical Specification 4.2.2.2.d.1.

100 Percent Power Flux Map:

On November 30, 1990 a full-core flux map was performed at 100% reactor power. This map served as a check for the incore/excore calibration and power distribution limits. The results of the map are shown in Table 2. The incore/excore calibration performed at 74% power was satisfactory. Analysis of the power distribution limits showed that Fxy exceeded its surveillance limit (Fxy ≥ Fxy(LIM)) by approximately 0.5% at axial point 45.

Westinghouse was notified of the Fxy measurement and was requested to analyze the margin to Fq limit. Westinghouse's analysis showed that in the region surrounding axial point 45, a 4 to 5 percent margin to Fq limit existed. Westinghouse provided written notification that Unit 2 could take credit for this margin and could justify continued full power operation of Cycle 3.

The 100% flux map marked the completion of the reload startup test program for Beaver Valley Power Station Unit 2, Cycle 3.

TABLE 1

CONTROL ROD BANK WORTHS

Bank	Measured Worth (pcm)	Predicted Worth (pcm)	Error (%)	Acceptance Criteria
CCB*	1286.50	1330	-3.27	± 10%
CBD	941.25	1003	-6.16	± 15%
CBC	733.44	802	-8.55	± 15%
CBA	628.34	664	-5.37	± 15%
SBB	882.98	973	-9.25	± 15%
SBA	1072.78	1106	-3.00	± 15%
Total Worth	5545.29	5878	-5.66	± 15%

* Reference Bank for Rod Swap.

TABLE 3

FULL CORE FLUX MAP SUMMARY

Parameters	30% Power CBD 183 steps	74% Power CBD 219 steps	90% Power CBD 225 steps	100% Power CBD 228 steps	Acceptance Criteria
Quadrant Tilt	1.0095	1.0168	1.0106	1.0106	≤ 1.02 for power above 50%
Maximum Deviation from Predicted Assembly Powers	6.4%	7.6%	6.6%	6.9%	± 10% for Predicted Relative Power > .9
F delta H	N/A	1.5446	1.5187	1.5248	Tech. Spec.: < 1.6681 for 74% < 1.6017 for 90% < 1.5560 for 100%
Fxy	N/A	1.7355	1.7062	1.7028	Tech. Spec.: < 1.7760 for 74% < 1.7276 for 90% < 1.6943 for 100% Fxy(RTP) = 1.69